Traffic shaping with OVS and SDN

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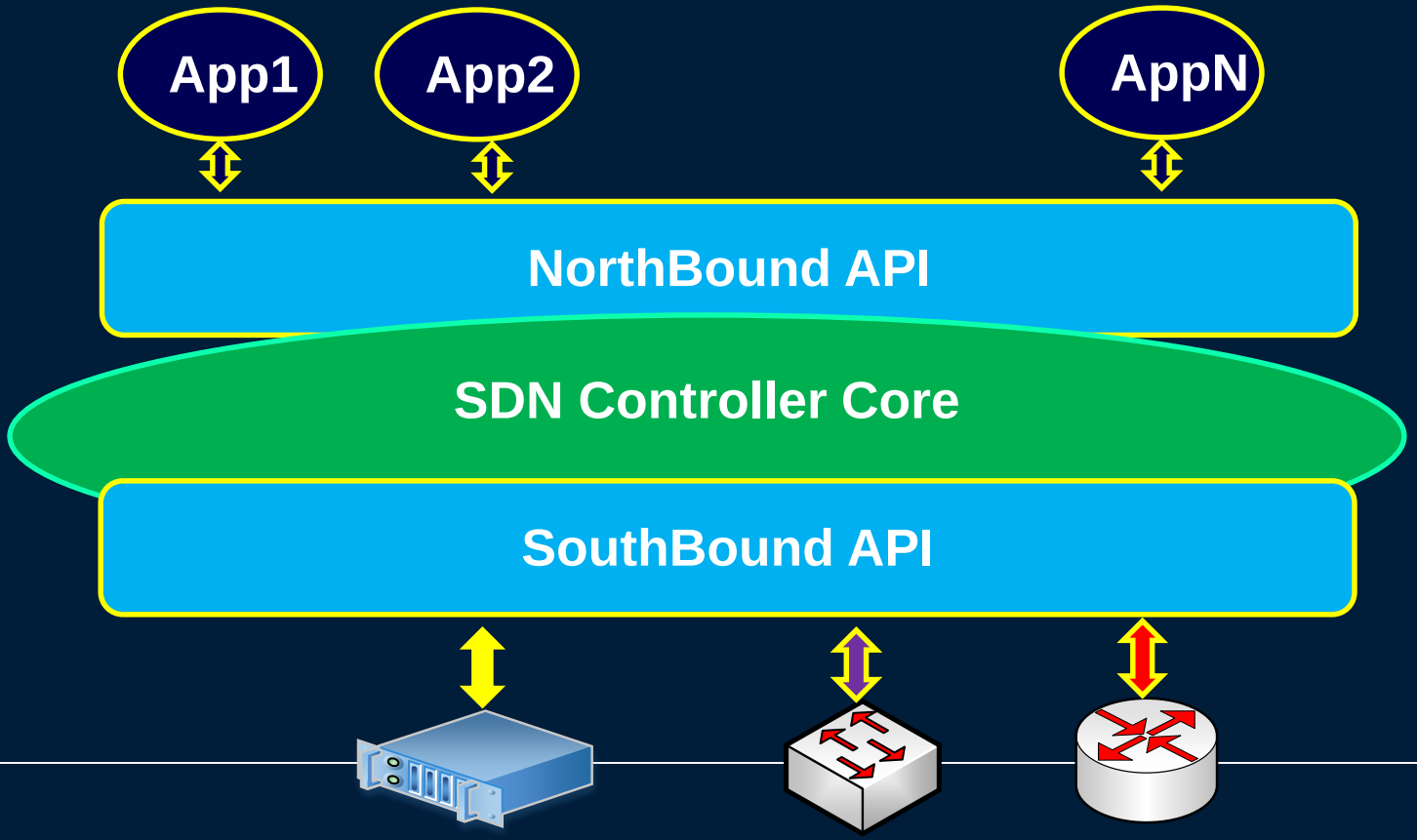
SDN Controllers

- **"Standard" SDN controller architecture**
  - NB: RESTfull/JSON, NETCONF, proprietary, etc
  - SB: OF, SNMP, NETCONF,



Design considerations for SDN control plane

- **Even at the site/cluster level the SDN control plane *should* support fault-tolerance and resilience**
  - e.g. in case one or multiple controller instances fail the entire *local* control plane must continue to operate
- **Each NE must connect to at lest two controllers (redundancy)**
- **Scalability**

SDN Controllers

- **NOX:**
  - First SDN controller
  - C++
  - New protocols development
  - Open source by Nicira in 2008
- **POX**
  - Python-based version of NOX
- **Ryu**
  - Python
  - Integration with OpenStack
  - Clustering: No SPOF using Zookeeper

ONOS: Open Network Operating System

- **"A SDN network operating system for Service Providers and mission critical networks"**
- **Distributed core designed for High-Availability and performance (RAFT consensus algorithm)**
- **Developed in Java - a set of OSGi modules deployed in an OSGi container (Karaf) – similar to ODL**
- **Application Intents to NB which can be compiled on the fly in (Flow) Rules for SB**
  - Intent: Request a service from the network without knowing how the service will be performed

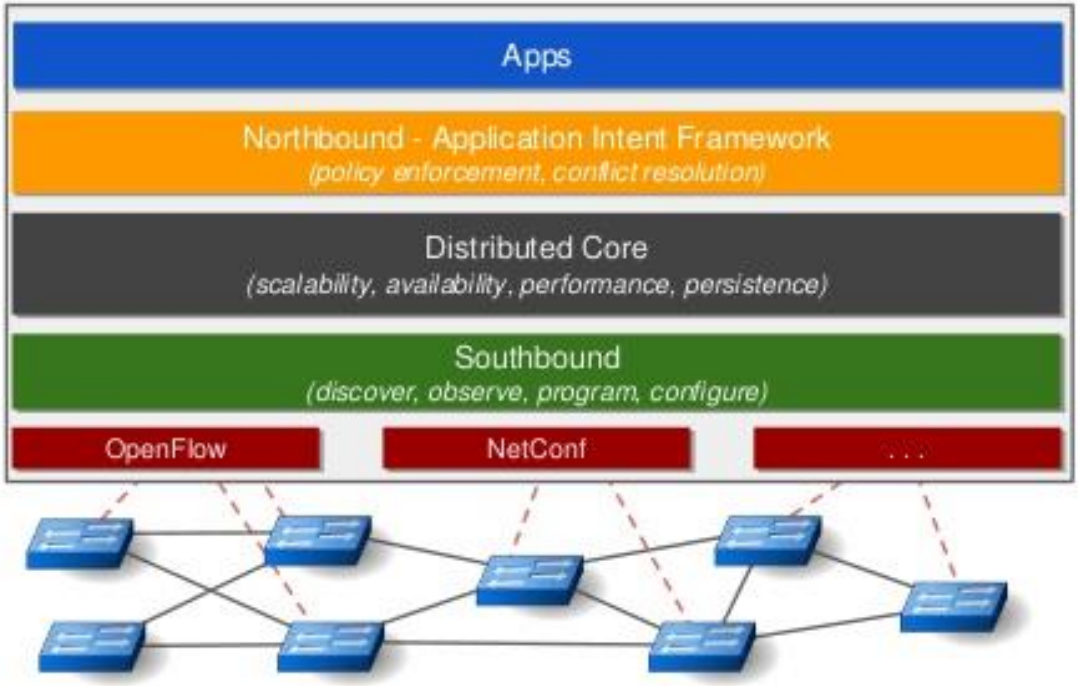
ONOS: Open Network Operating System

ONOS Architecture Tiers

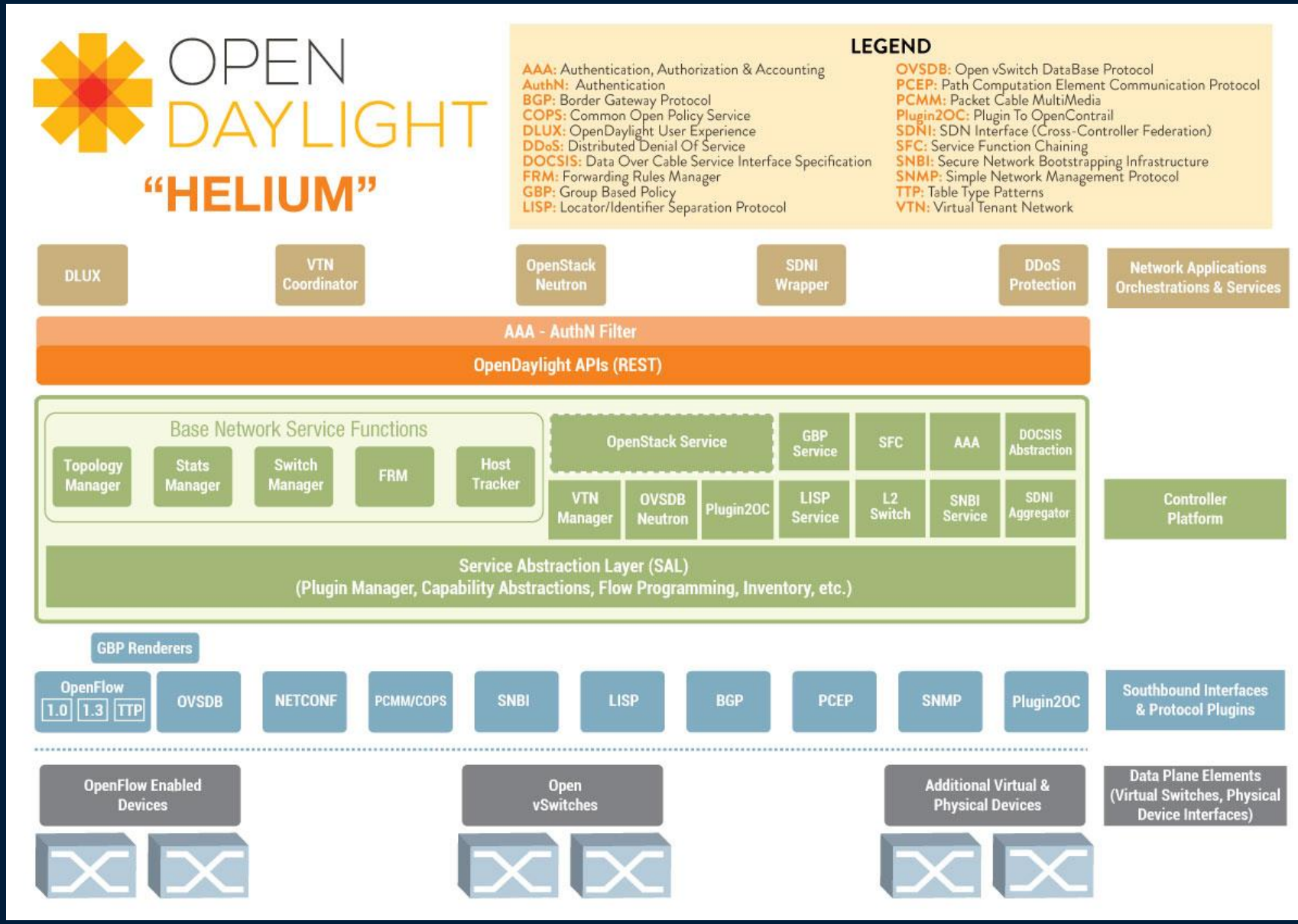
Northbound Abstraction:
- network graph
- application intents

Core:
- distributed
- protocol independent

Southbound Abstraction:
- generalized OpenFlow
- pluggable & extensible



OpenDaylight “Helium”



OpenDaylight “Helium”

- Project under Linux Foundation umbrella
- Well-established and very active community (very likely the biggest)
- Developed in Java - a set of OSGi modules deployed in an OSGi container (Karaf) – similar to ONOS
- Backed up by leading industry partners
- Distributed clustering based on Raft consensus protocol
- OpenStack integration
- “Helium” is the 2nd release of ODL and supports, apart from SDN, NV (Network Virtualization) and NFV (Network Function Virtualization)

OVS Open vSwitch

"Open vSwitch is a production quality, multilayer virtual switch"

- OpenFlow protocol support (1.3)
- Kernel and user space forwarding engines
- Runs on all major Linux distributions used in HEP[*]
- NIC bonding
- Fine grained QoS support
  - Ingress qdisc, HFSC, HTB
- Used in a variety of hardware platforms (e.g. Pica8) and software appliances like Mininet
- Interoperates with OpenStack

- OVN (Open Virtual Network): Virtualized network "*implemented on top of a tunnel-based (VXLAN, NVGRE, IPsec., etc) overlay network*"

[*] For SL/CentOS/RH 6.x some patches had to be applied. Custom RPMs

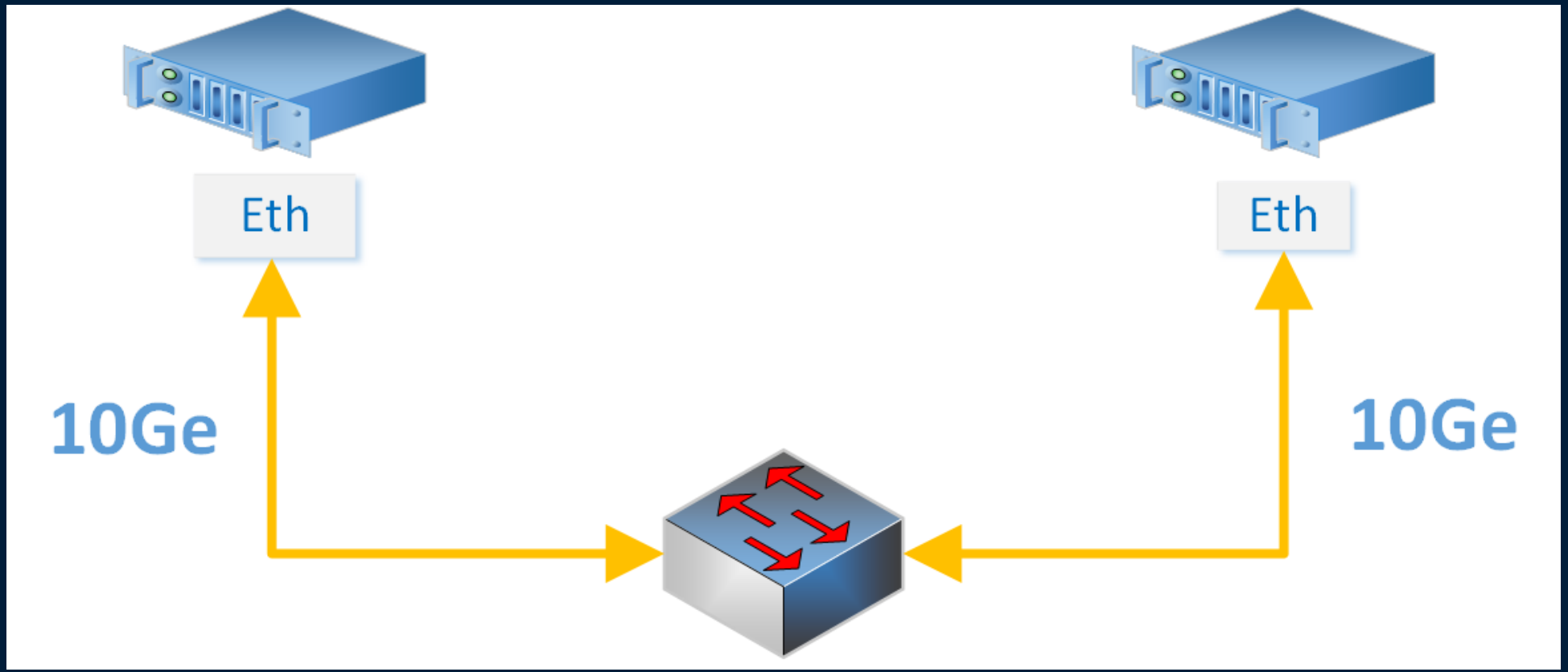
OVS Open vSwitch

Performance tests

- Compared the performance of hardware versus the OVS in two cases:
  - Bridged network (the physical interface becomes a port in the OVS switch)
  - Dynamic bandwidth adjustment

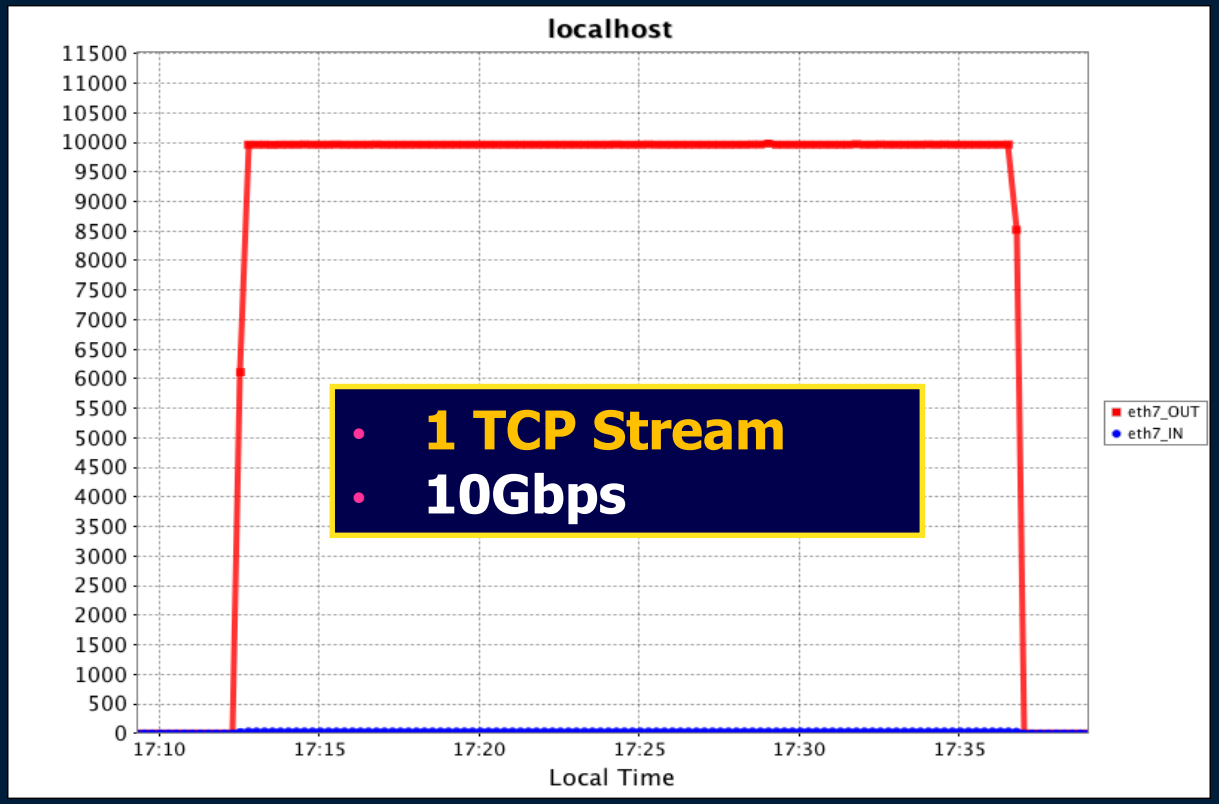
Baseline performance tests (10Ge)

- Two SanyBridge machines
- 10Ge Mellanox cards ("back-to-back")
- Stock SLC 6.x kernel
- Connected via Z9K



Baseline performance – hardware throughput (single stream)

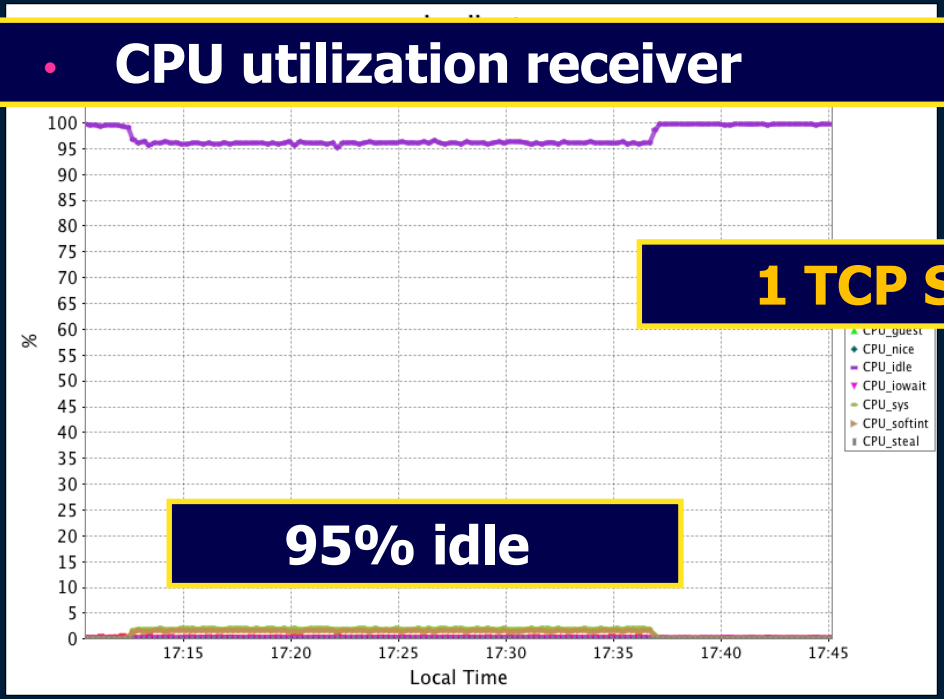
- FDT nettest (memory to memory)



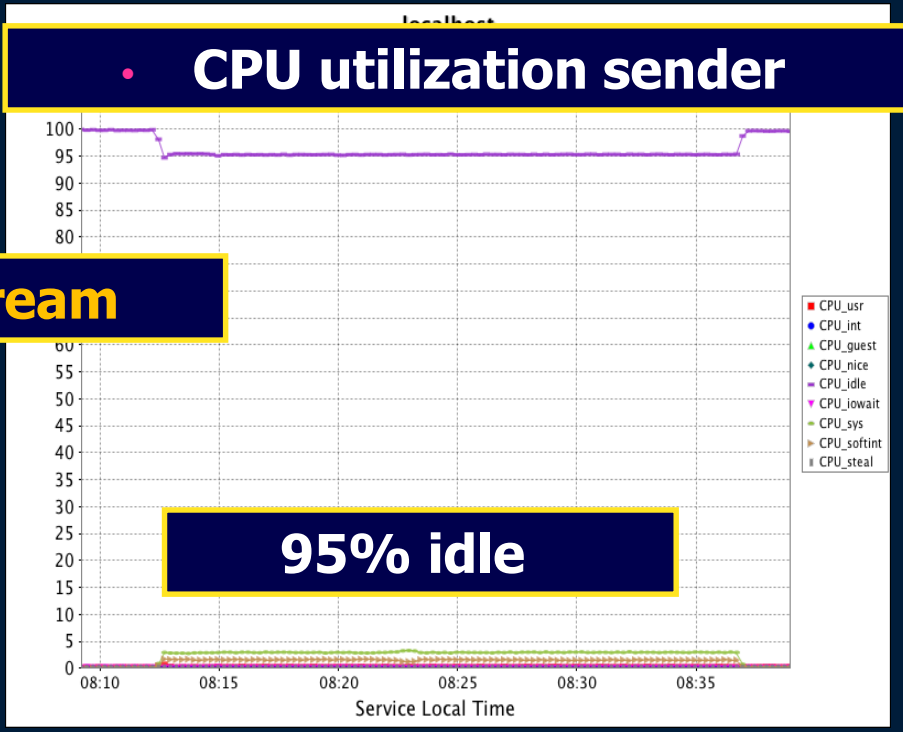
Baseline performance (single stream)

- FDT nettest (memory to memory)
- Line rate 10Gbps

- CPU utilization receiver



- CPU utilization sender



1 TCP Stream

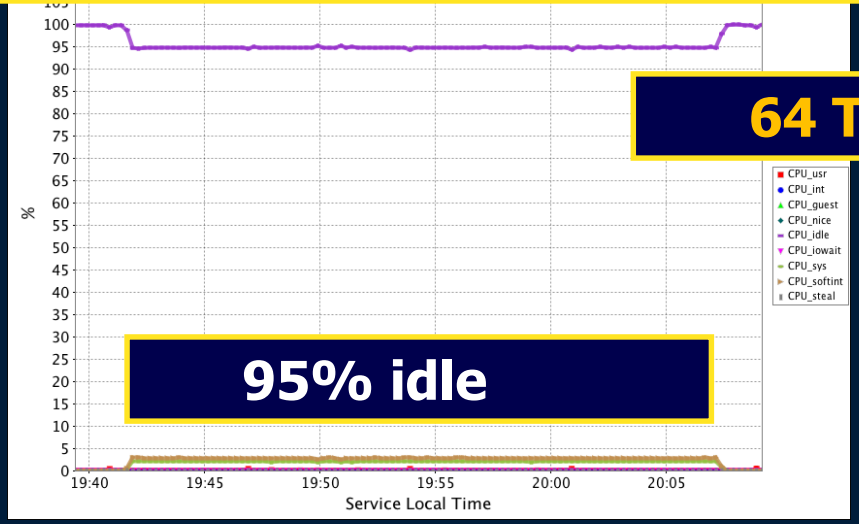
95% idle

95% idle

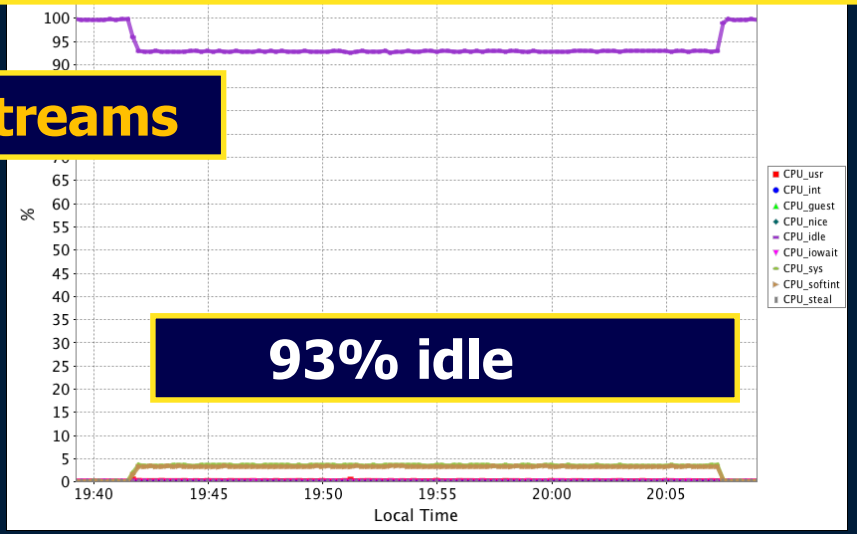
Baseline performance (multiple stream)

- FDT nettest (memory to memory)
- CPU Usage:
  - Receiver: ~95% Idle
  - Sender: ~92% Idle (64 streams), 90% Idle (128 streams)
- Similar results with 8, 16, 32, 64 and 128 TCP streams

- CPU utilization receiver



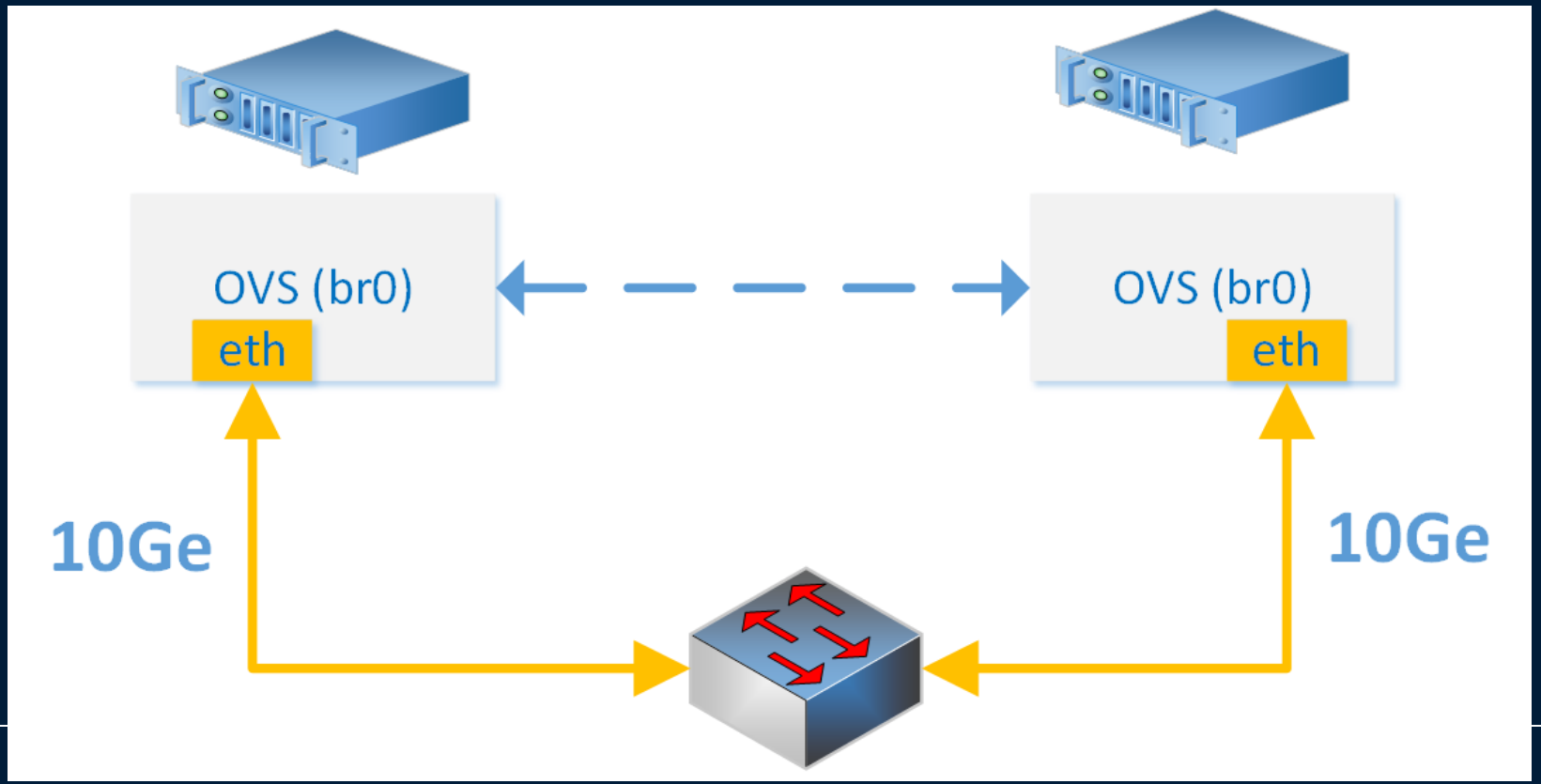
- CPU utilization sender



64 TCP Streams

Performance tests – OVS Setup

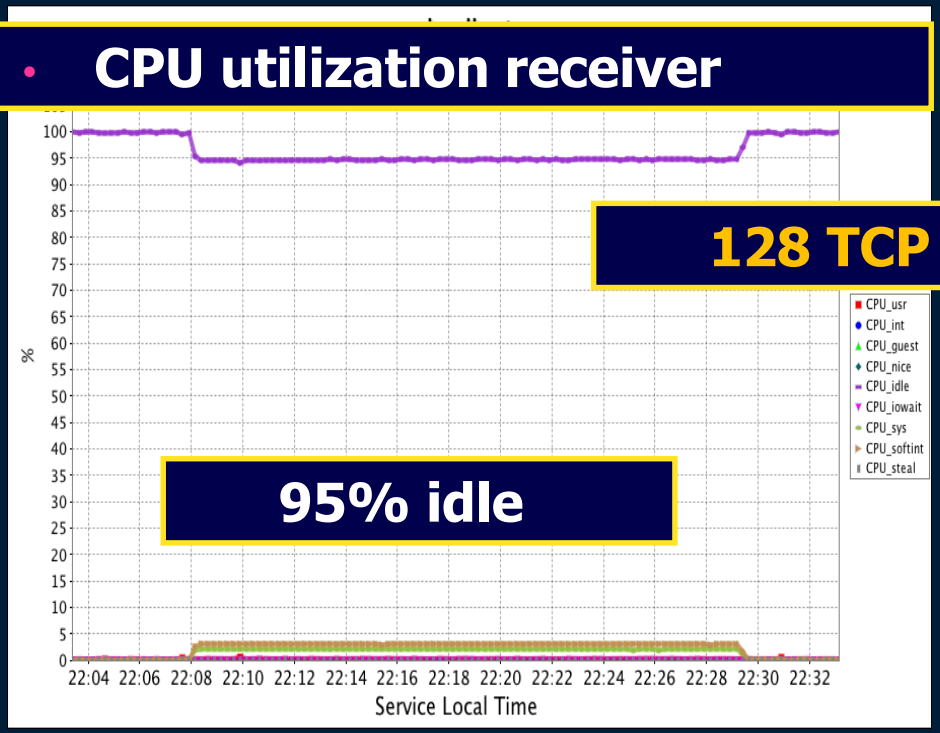
- Same hardware
- OVS 2.3.1 on stock SLC(6) kernel
- Same eth interfaces added as OVS interfaces
  - ovs-vsctl add port br0 eth5



OVS performance

- FDT nettest (memory to memory)
- Line rate 10Gbps
- Slightly decreased performance for receiver

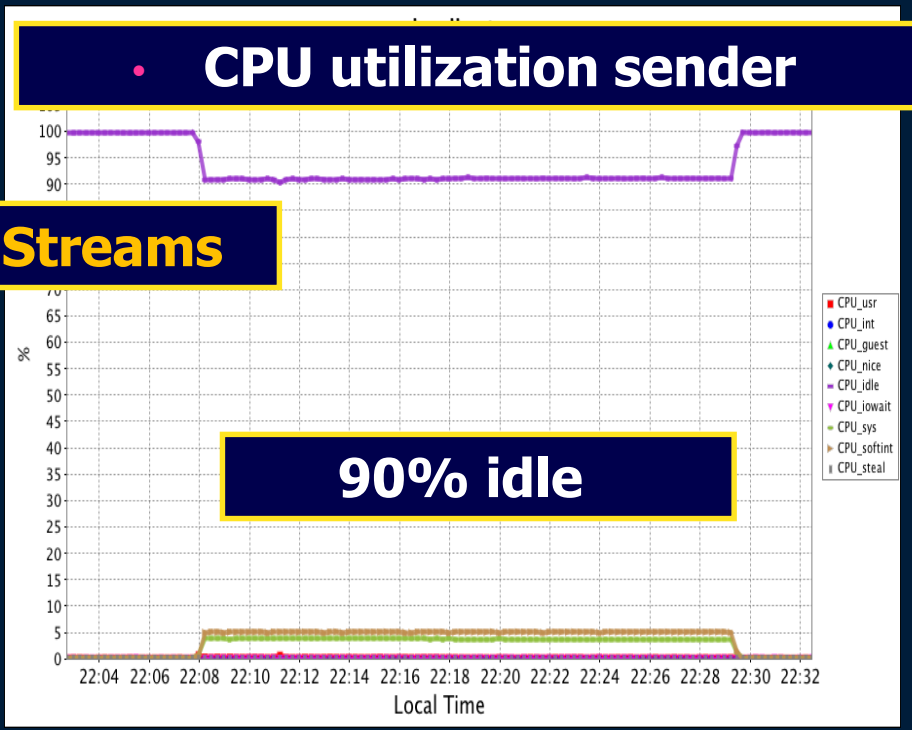
- CPU utilization receiver



95% idle

128 TCP Streams

- CPU utilization sender



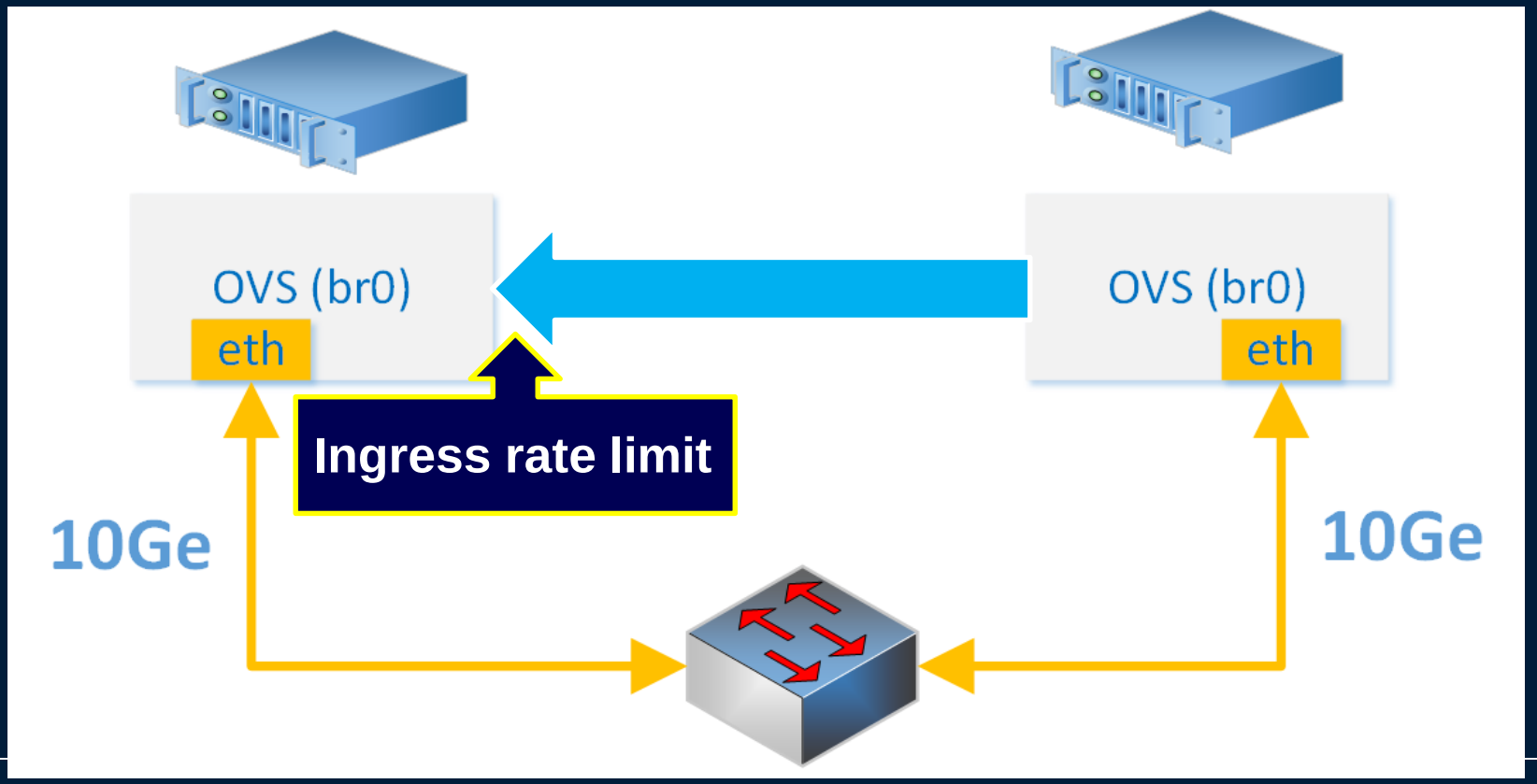
90% idle

Conclusions: Baseline performance tests

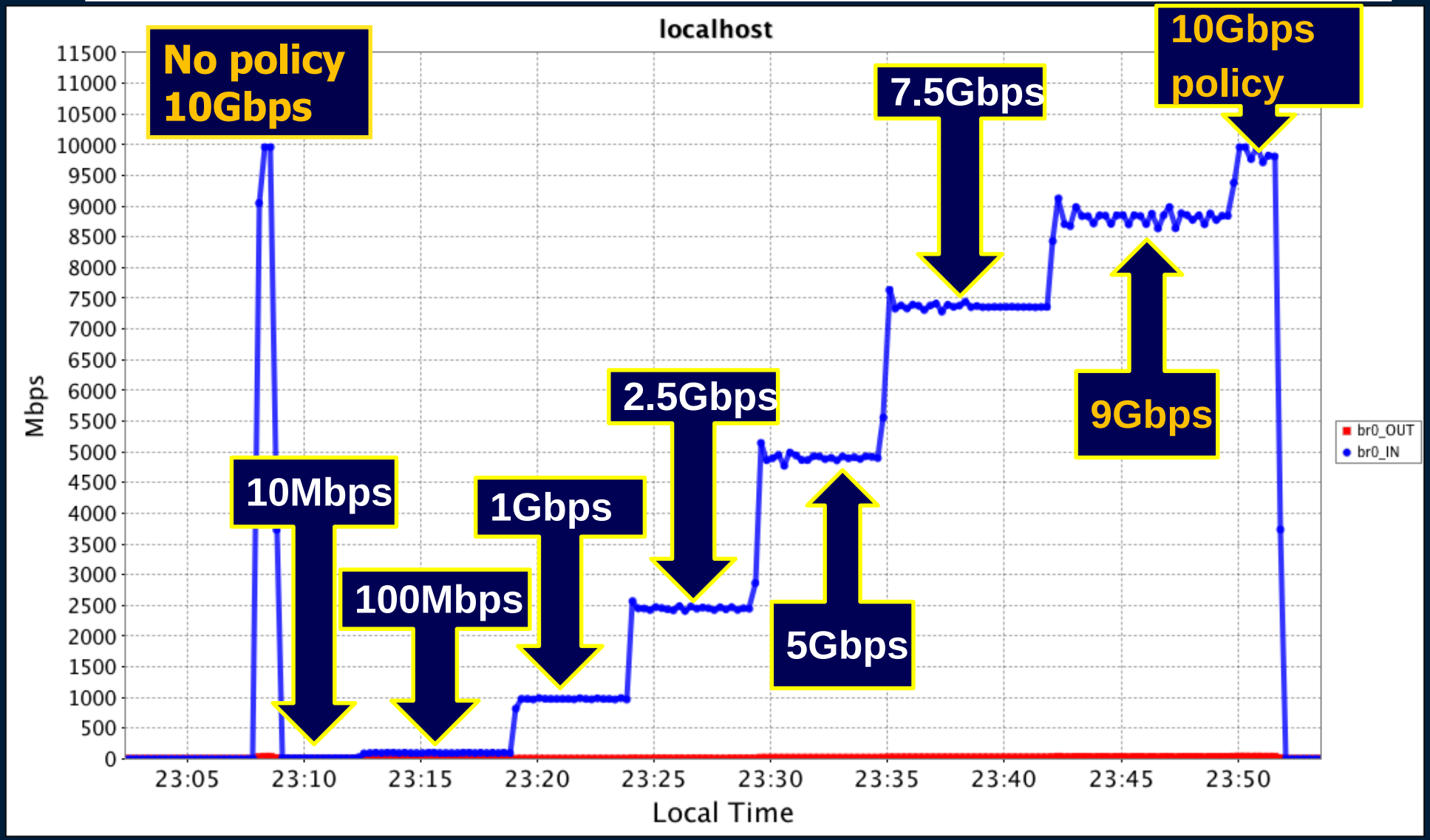
- TCP tests with a range of multiple TCP streams varying from 1 up to 128
- Line rate in all the tests: 10Gbps
- CPU usage between 5% and 10% (normal scenario with <64 streams would be 95% CPU idle)
- OVS 2.3.1 with *stock* SL/CentOS/RH 6.x kernel
- OVS bridged interface achieved the same performance as the hardware (10Gbps)
- No CPU overhead for OVS in this scenario

OVS Dynamic bandwidth adjustment
Ingress rate-limit

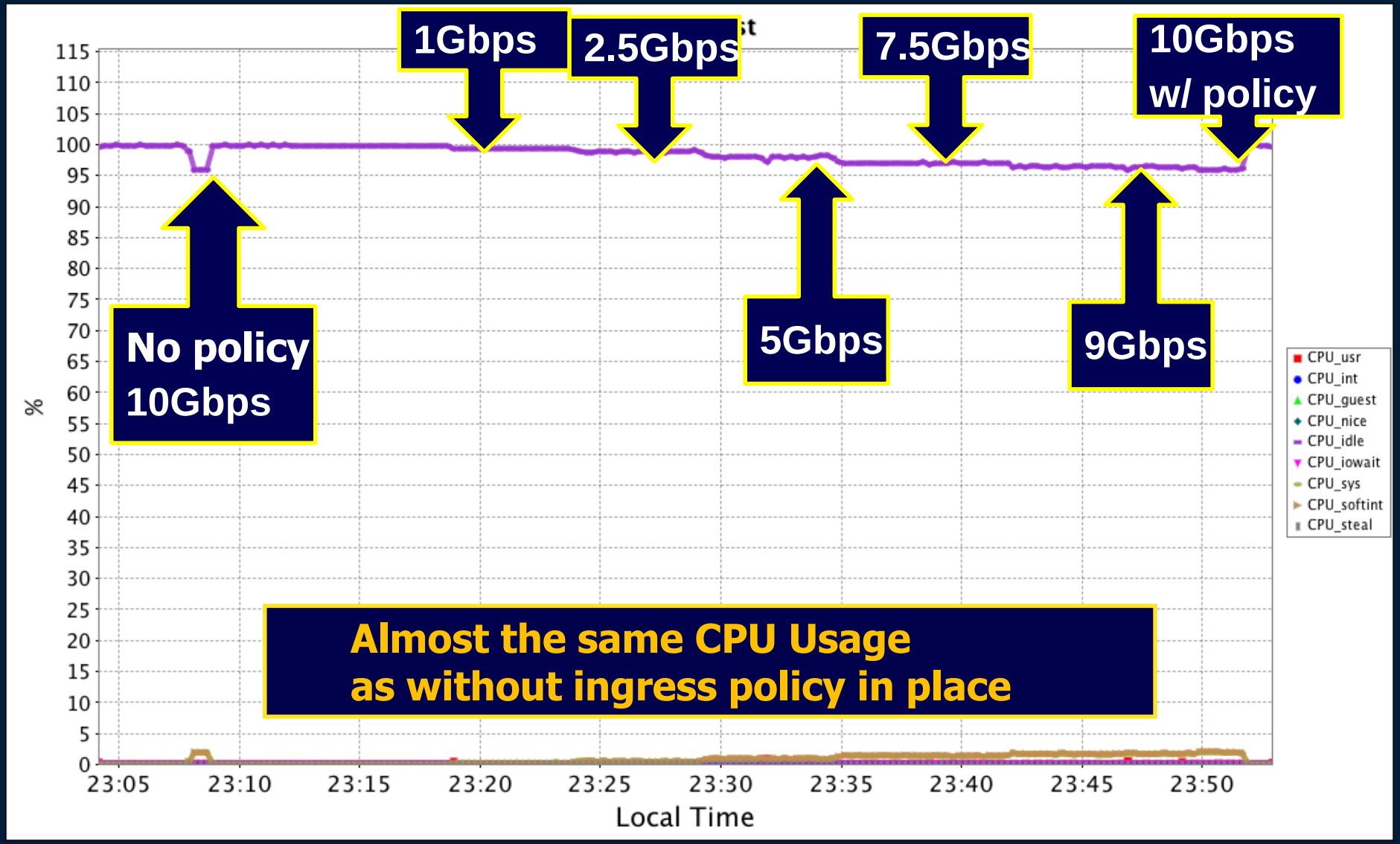
- OVS ingress rate-limit
- Adjust per interface
  - Based on Linux kernel ”ingress qdisc”



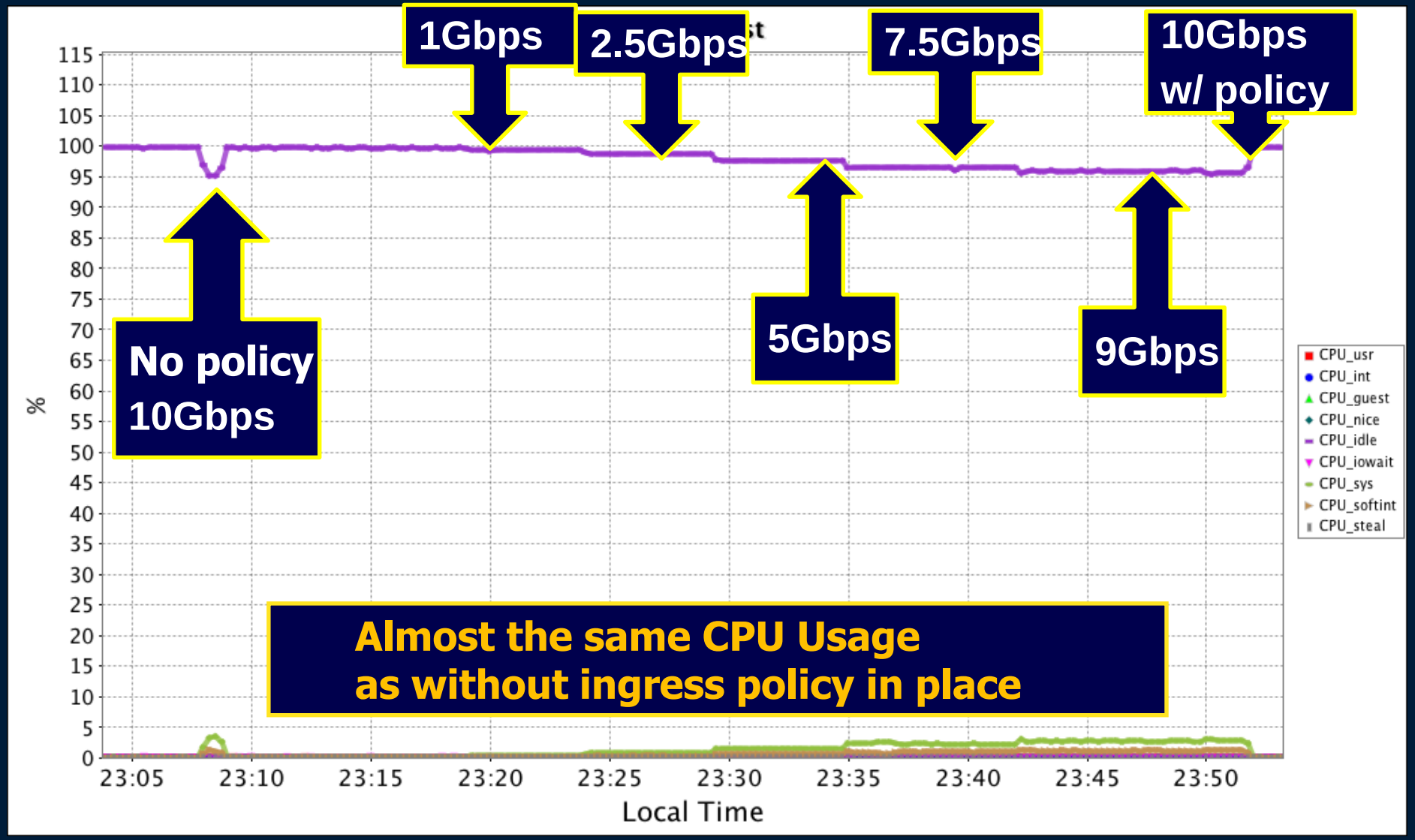
OVS Dynamic bandwidth adjustment
Ingress rate-limit



OVS Dynamic bandwidth adjustment
Ingress rate-limit – Receiver CPU

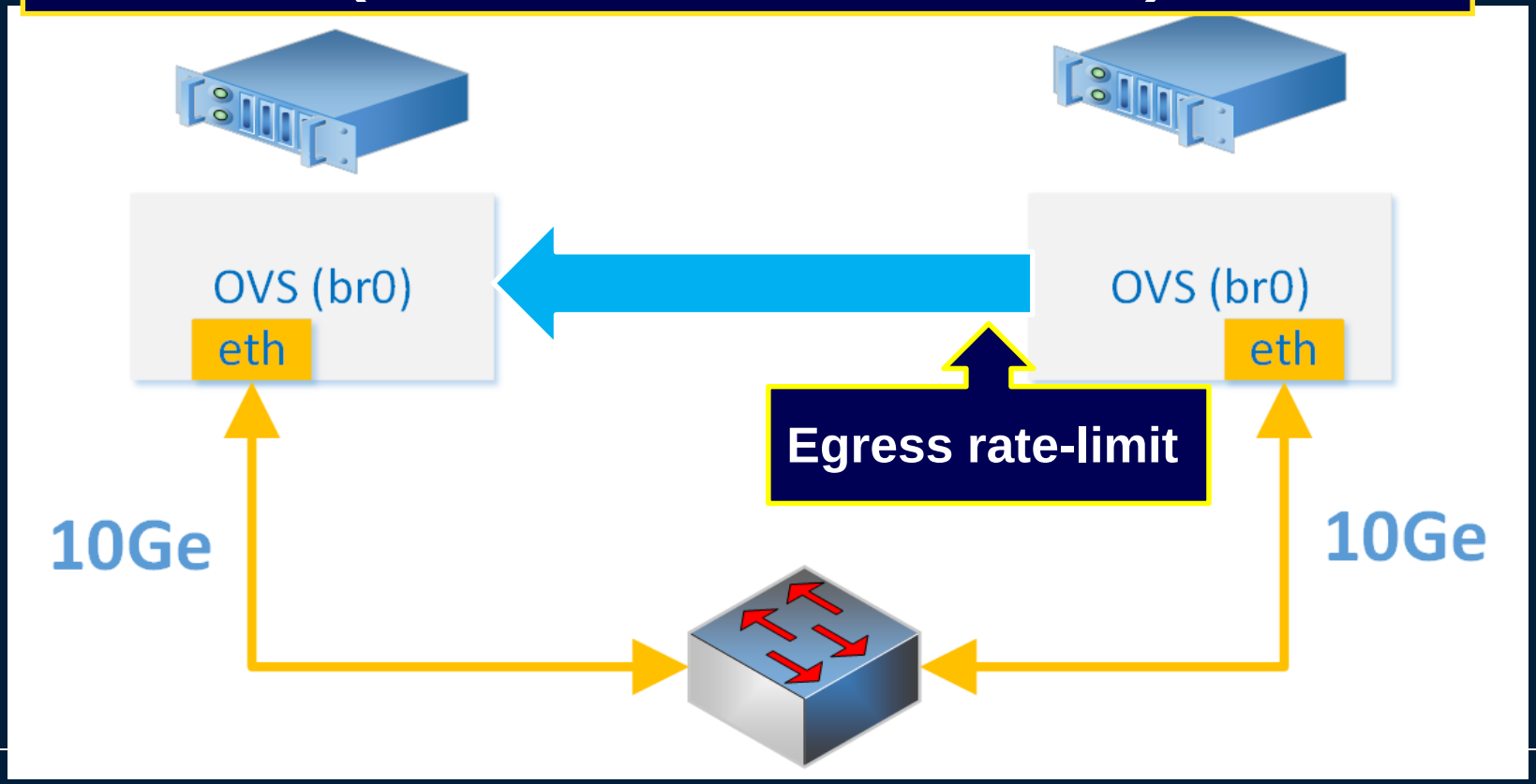


OVS Dynamic bandwidth adjustment
Ingress rate-limit – Sender CPU

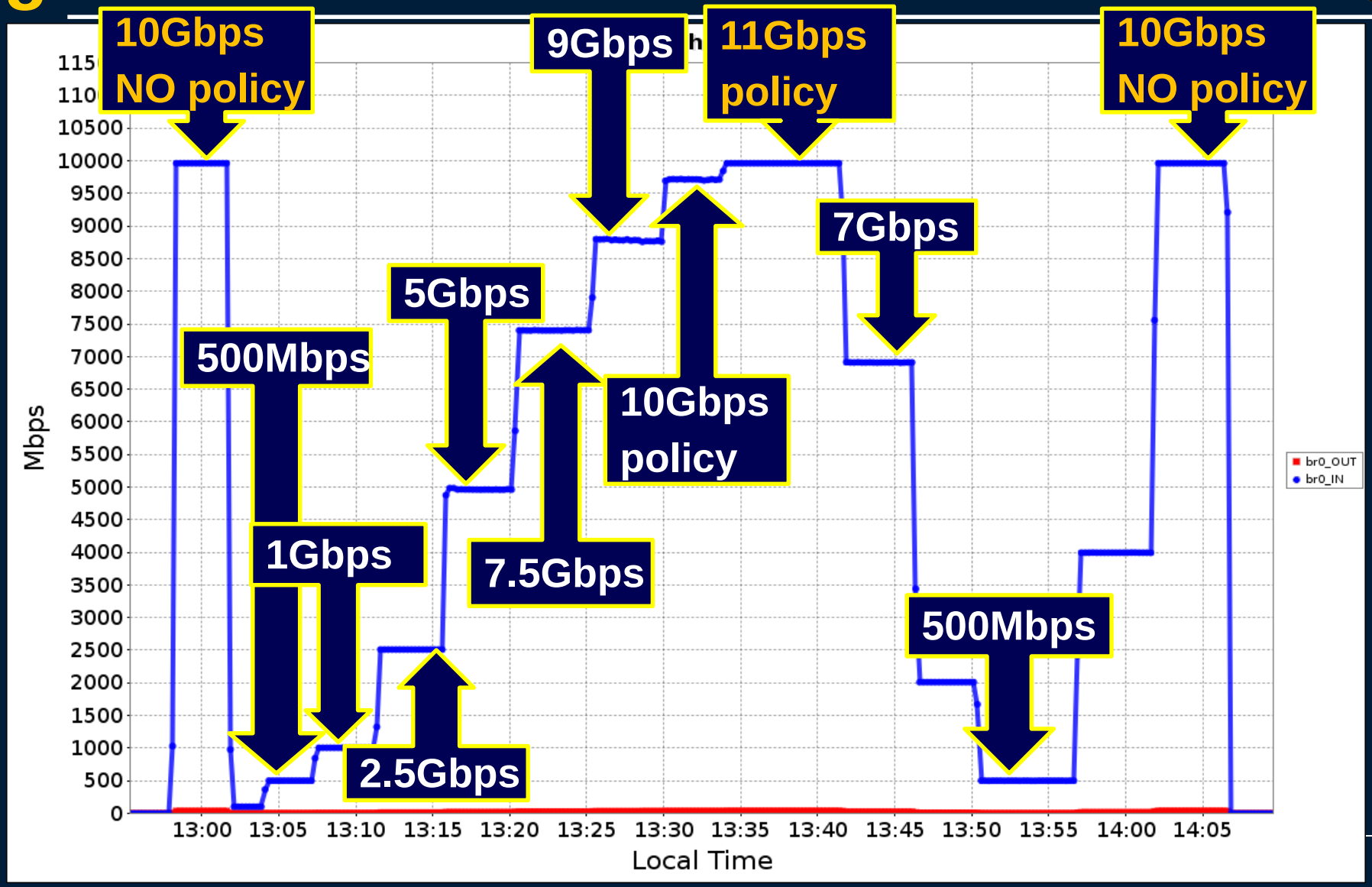


OVS Dynamic bandwidth adjustment

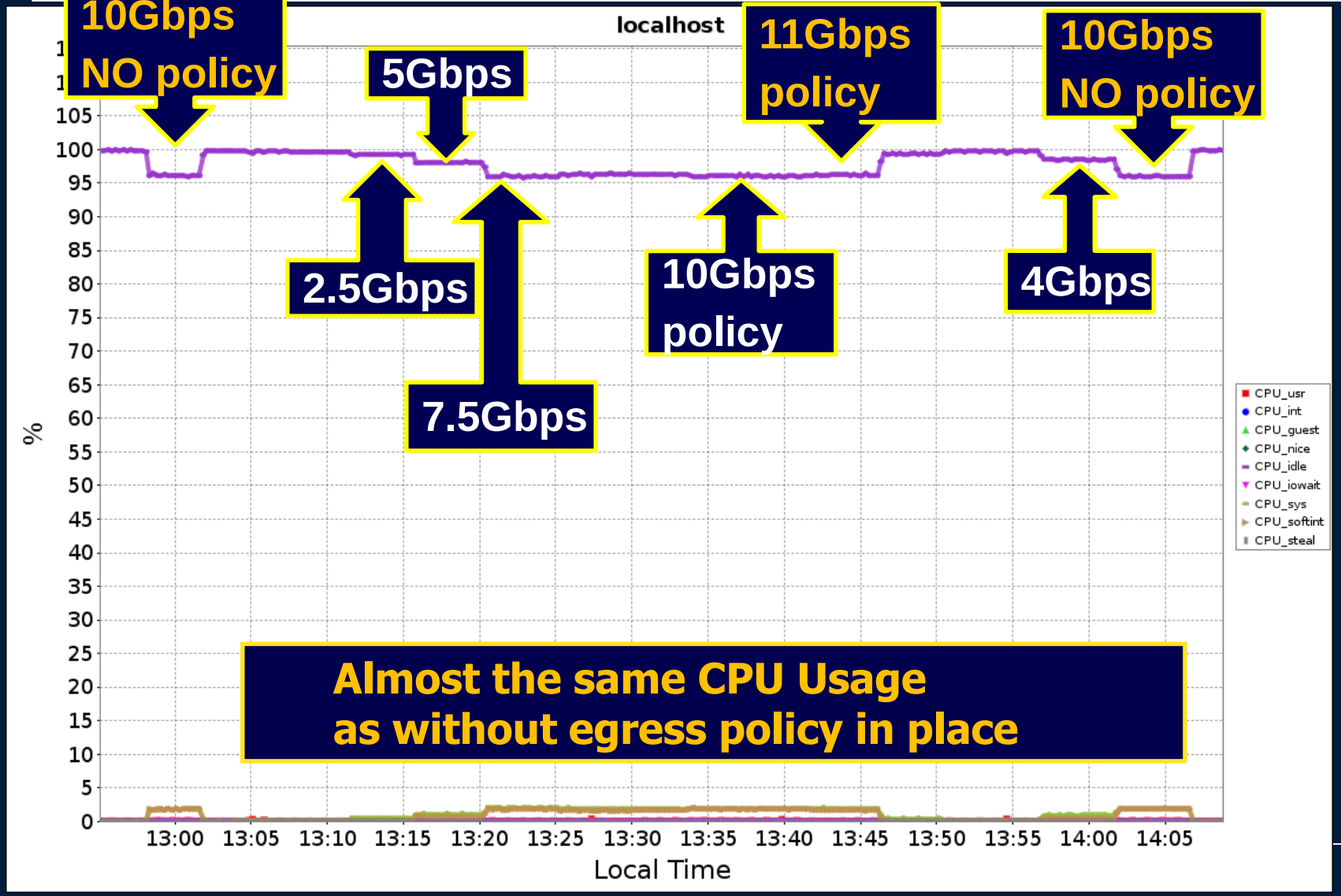
- OVS egress rate-limit
- Based on Linux kernel:
  - HTB (Hierarchical Token Bucket)
  - HFSC (Hierarchical Fair-Service Curve)



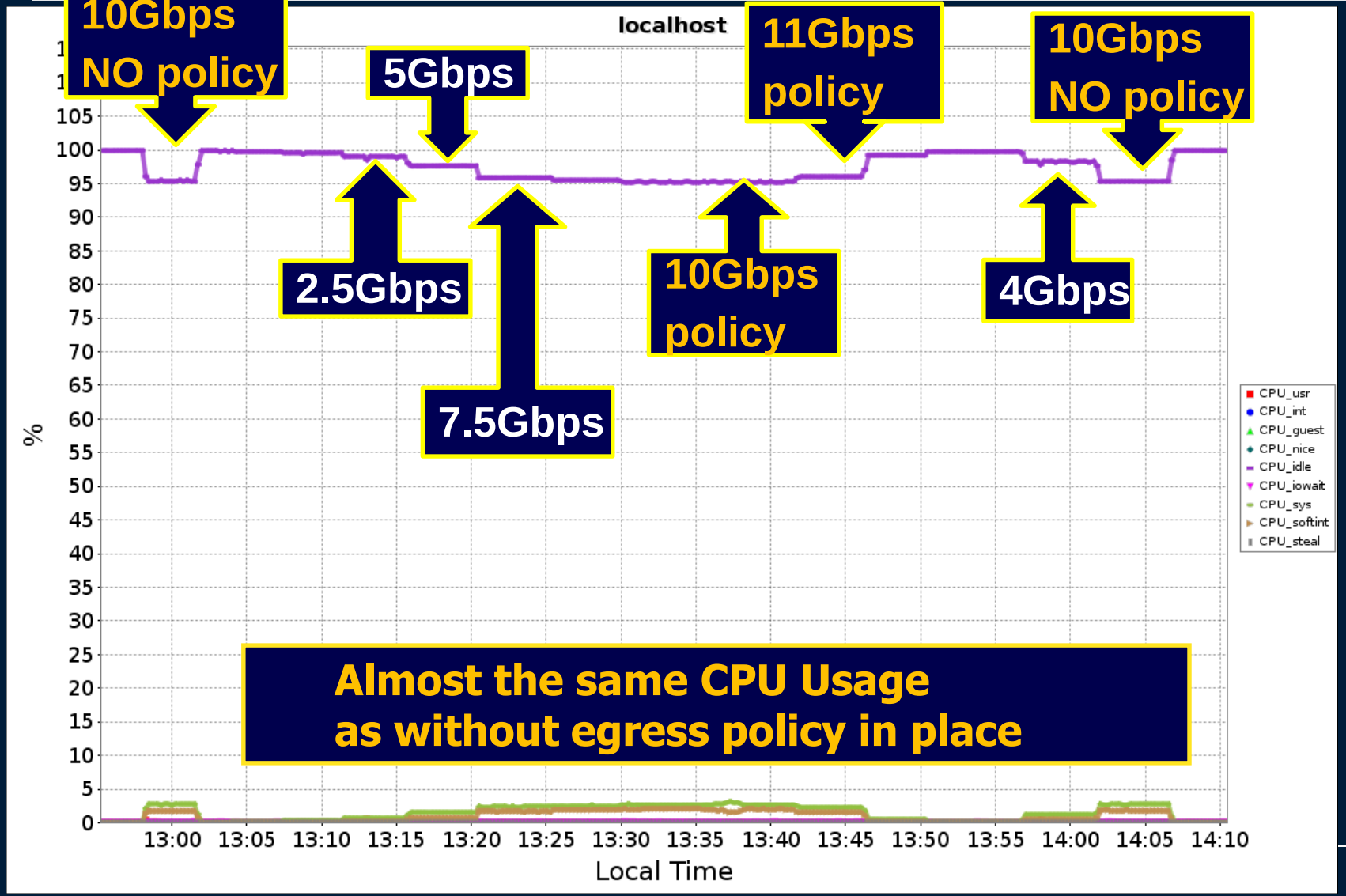
OVS Dynamic bandwidth adjustment egress rate-limit



OVS Dynamic bandwidth adjustment egress rate-limit



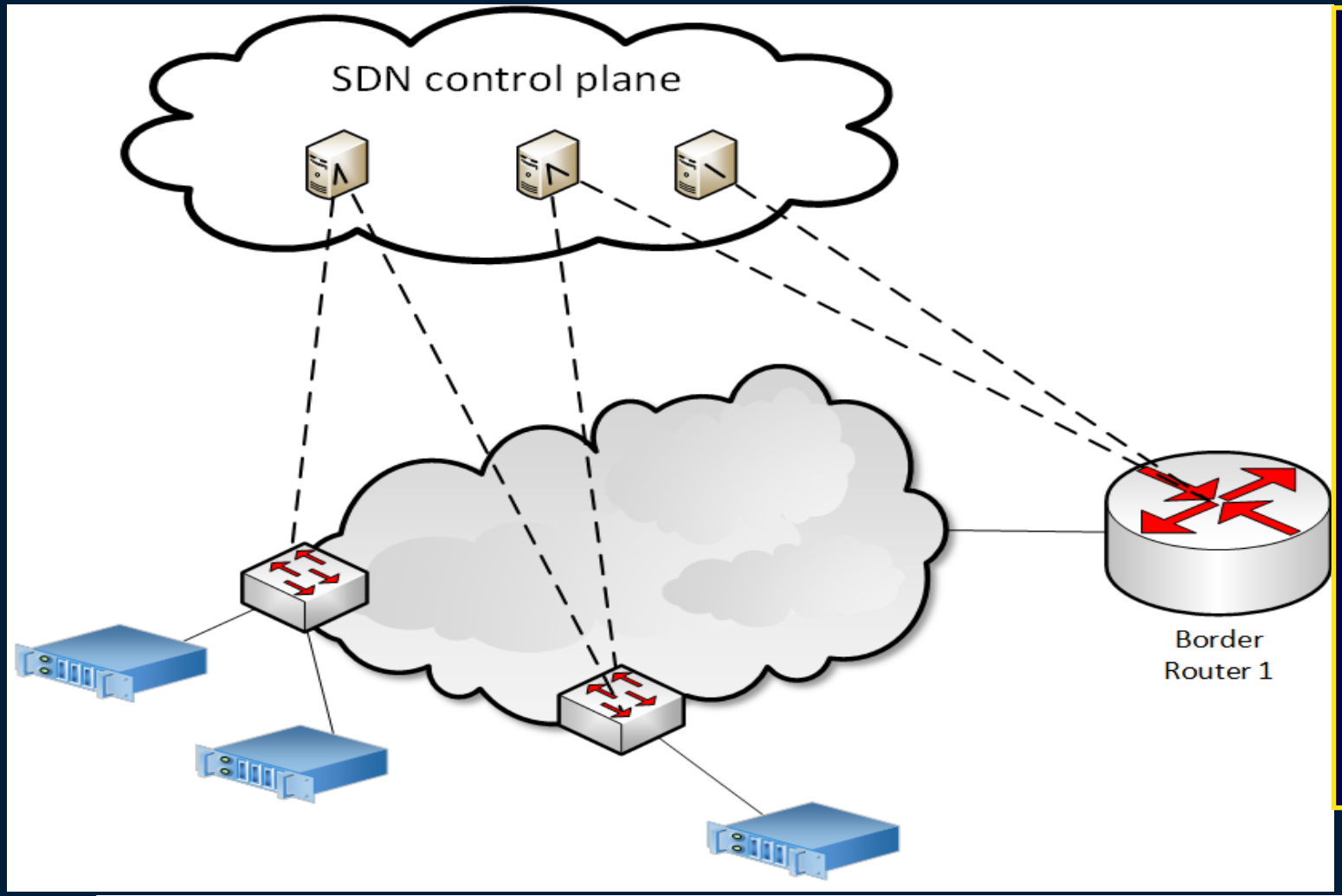
OVS Dynamic bandwidth adjustment egress rate-limit– Sender CPU



Conclusions:
OVS Dynamic bandwidth adjustment

- Smooth egress traffic shaping up to 10Gbps, and up to 7Gbps for ingress
- Over long RTT the ingress traffic shaping may not perform well (needs more testing), especially above 7Gbps
- The CPU overhead is negligible when enforcing QoS
- More testing is needed:
  - Longer RTTs
  - 40Ge? (are there any storage nodes with 40Ge yet)
  - Multiple QoS queues for egress
  - reliability over longer intervals

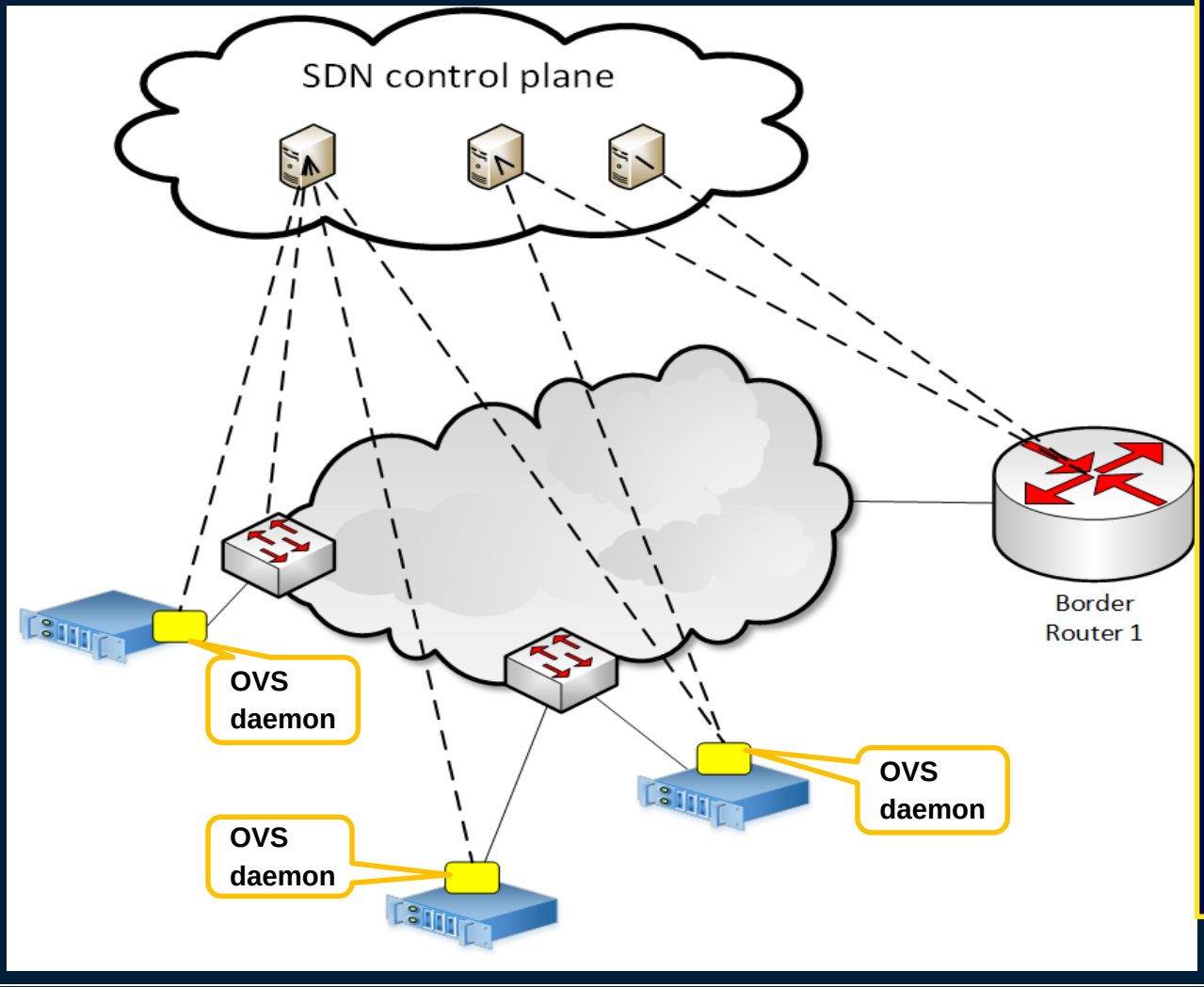
SDN-enabled site (1)



All NEs controlled by a *redundant* SDN control plane

The entire SDN resides within the network layer

SDN-enabled site (2)



OVS daemon runs on the end-host

May evolve in a site with SDN-controlled NEs

OVS is "ready" to be deployed today without any impact on the current operations

Possible OVS benefits

- The controller gets the "handle" all the way to the end-host
- Traffic shaping (egress) of outgoing flows may help performance in cases where upstream switch has smaller buffers
- A SDN controller may enforce QoS in non-OpenFlow clusters
- OVS 2.3.1 with *stock* SL/CentOS/RH 6.x kernel
- OVS bridged interface achieved the same performance as the hardware (10Gbps)
- No CPU overhead for OVS in this scenario